APPENDIX G

CALIFORNIA AIR RESOURCES BOARD
HEALTH RISK ASSESSMENT METHODOLOGY
FOR HARBORCRAFT AND INTRASTATE LOCOMOTIVES

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Methodology

This appendix presents the methodology used to estimate the potential cancer risk from exposure to diesel particulate matter (PM) emissions from intrastate locomotives and harbor craft activities**.** This methodology was developed to assist in the development of the *Proposed Regulatory Amendments Extending the California Motor Vehicle Diesel Standards to Diesel Fuel Used in Harborcraft and Intrastate Locomotives.* The assumptions used to determine these risks are not based on a specific intrastate locomotive or harbor craft activity pattern. Instead, source parameters that represent possible operating scenarios were used. These estimated risks are used to provide an approximate range of potential risk levels from intrastate locomotive and harbor craft activities. Actual risk levels will vary due to site specific parameters, including the number of locomotives or harbor craft, the operation or activity, emission rates, operating schedules, site configuration, site meteorology, and distance to receptors.

The methodology used in this risk assessment is consistent with the Tier-1 analysis presented in the OEHHA, Air Toxics Hot Spots Program Risk Assessment Guidelines: The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2003). These OEHHA guidelines and this assessment utilize health and exposure assessment information that is contained in the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (OEHHA, 2003); and the Air Toxics Hot Spot Program Risk Assessment Guidelines, Part IV, Technical Support Document for Exposure Analysis and Stochastic Analysis (OEHHA 2000), respectively.

A. Source Description

To provide an estimate of the potential cancer risks associated with exposure to diesel PM emissions associated with intrastate locomotives and harbor craft, ARB staff developed two scenarios. The first scenario examined the potential cancer risk for excursion or ferry vessel activities at a port. The second scenario examined the potential cancer risk from the operation of a short-haul locomotive passing through a residential neighborhood.

In the first scenario, the excursion or ferry vessel activities were characterized as three point sources of emissions from the two diesel fueled propulsion engines and one diesel fueled auxiliary engine. The engine sizes at 100 percent load were estimated to be 750 horsepower (hp) for propulsion and 100 hp for auxiliary based on the ARB's statewide survey. The engines operation load factors are assumed to be 10 percent (idling) for the propulsion engines and 43 percent for the auxiliary engine. The hourly diesel PM emission rate for the propulsion engines was assumed to be 0.5 grams per brake horsepower per hour (g/bhp-hr) based on Bay Area Water District Authority emission testing. The test was performed in 2002 at MV Mare Island.

The auxiliary engine diesel PM emission rate used in this analysis is 0.84 g/bhp-hr based on the ARB OFFROAD emission factors for generators (engine population weighted average). The operating scenario was modeled as one vessel operating from 6:00 AM to 6:00 PM daily.

For the locomotive scenario, the emission source was modeled as a series of volume sources with the width of 30 meters along a 1-mile segment traveling at 40 miles per hour (mph) at a load setting of notch 5. The traffic volume for this source included 10 trains per day, each with 2 locomotives operating 24 hours per day for 365 days per year. The locomotive engine emission factor is 362 g/hr based on the fleet weighed average of notch 5 for eleven (11) locomotive models in California.

B. Dispersion Modeling Methods

The dispersion of diesel PM emissions was estimated using the United States Environmental Protection Agency (U.S. EPA) ISCST3 (version 00101). ISCST3 can estimate potential ambient annual average concentrations of diesel PM as a result of diesel PM emissions from point, area, volume, and pit sources.

The analyses used actual meteorological data collected at three meteorological sites, West Los Angeles (1981), Long Beach (1981), and Richmond (1998). Cartesian grid coordinate receptors were placed at specific incremental distances from the sources to determine the off-site impacts. Table 1 shows the dispersion modeling parameters used to model impacts of diesel PM emissions from an excursion or ferry vessel. Table 2 shows the dispersion modeling parameters used to model impacts of diesel PM emissions from short-haul locomotive operations.

Table 1: Dispersion Modeling Parameters for Excursion/Ferry Vessel Activities

Modeling Parameters	
Model	ISCST3 (Version 00101)
Source Type	Point
Dispersion Coefficients	Urban
Number of Engines per Excursion Vessel	2 propulsion engines, 1 auxiliary
Engine Horsepower (at 100% load)	750 hp for propulsion, 100 hp for auxiliary
Engine Operation Load	10% for propulsion (idling), 43% for auxiliary
Emission Factor	0.50 g/bhp-hr for propulsion, 0.84 g/bhp-hr for auxiliary
Operation Schedule	6 am to 6 pm every day, 1 vessel per hour
Receptor Height	1.5 m
Stack Information:	
Stack Diameter	8” for propulsion, 3” for auxiliary
Stack Height	10 m for all engines
Exhaust Temperature	350 ^{o}K for propulsion, 550 ^{o}K for auxiliary
Exhaust Velocity	6 m/s for propulsion, 23 m/s for auxiliary
Meteorological Data	West Los Angeles (1981), Long Beach (1981), Richmond (1998)
Release Height	Same as the stack height

Table 2: Dispersion Modeling Parameters for Short-Haul Locomotives

Modeling Parameters	
Model	ISCST3 (Version 00101)
Source Type	Volume
Dimension of Modeling Domain	1 mile segment with width of 30 m
Dispersion Coefficients	Urban
Traffic Volume	10 trains/day, each with 2 locomotives
Engine's Emission Factor	362 g/hr (Notch 5)
Train Travel Speed	40 mph
Operation Schedule	24 hr/day, 365 days/yr
Receptor Height	1.5m
Meteorological Data	West L. A. (1981), Long Beach (1981), Richmond (1998)
Release Height	5 m

C. Health Risk Assessment Methods

The dispersion model-predicted offsite concentrations were used to estimate potential cancer risk due to emissions of diesel PM. Under current OEHHA recommended risk assessment methodology, to estimate potential cancer risks, the estimated maximum annual ground level concentration (GLC), in micrograms per cubic meter ($\mu g/m^3$), is converted to a pollutant dose. Multiplication of the average daily inhalation dose over 70 years, in milligrams per kilogram of body weight per day (mg/kg-d), with the inhalation cancer potency factor developed by OEHHA will give the inhalation cancer risk. Unit risk factors (URF), in the units of inverse concentration, $(\mu g/m^3)^{-1}$, used in previous assessments can be used for assessing cancer inhalation risk directly from air concentrations. However breathing rates, expressed in units of liters per kilogram of body weight-day coupled with the air concentrations to estimate dose in mg/kg-d is recommended for assessing cancer risks. The diesel exhaust PM inhalation cancer potency factor used for this analysis is 1.1 with units of inverse dose as a potency slope, (i.e., $(mg/kg\text{-}d)^{-1}$).

Table 3 shows the risk assessment parameters used in these analyses for excursion or ferry vessel and short-haul locomotive activities.

Table 3: Risk Assessment Parameters Used in Analyses

Receptor Hypothetical Exposure Time	70 years, 50 weeks per year
Adults Daily Breathing Rate Range	271 – 393 l/kg body weight-day
Adults Body weight	70 kg
Diesel PM Inhalation Potency Factor	1.1 $(mg/kg\text{-}day)^{-1}$

D. Health Risk Assessment Results

Table 4 presents the estimated range of potential cancer health risks at nearby receptor locations due to exposures to the diesel PM emissions from excursion or ferry vessel activities at a port. Table 5 presents the estimated range of potential cancer health risks at nearby receptor locations due to exposures to the diesel PM emissions from short-haul locomotive activities.

As is shown in Table 4, based on the analysis, the estimated potential cancer risks for persons exposed to the diesel PM emissions from a hypothetical excursion/ferry vessel in a port, ranged from 50 to 280 potential cancer cases in a million at a downwind distance of 200 meters away from the emission source. The low end represents the 65th percentile breathing rate results using the Richmond meteorological data and the high end represents the 95th percentile breathing rate results using the West L. A. meteorological data.

For the locomotive scenario, as shown in Table 5, operating a short-haul line resulted in potential cancer risks ranging from 2 to 12 in a million at a downwind distance of 200 meters away from the edge of the locomotive railroad activity.

Table 4: Estimated Cancer Risk (per million) from Excursion/Ferry Vessel Activities

Downwind	Downwind	West L. A.		Long Beach		Richmond	
Distance (meter)	Distance (mile)	65th BR	95th BR	65th BR	95th BR	65th BR	95th BR
100	0.063	610	886	338	491	169	245
200	0.125	191	277	125	181	53	76
400	0.25	52	76	41	60	14	21
800	0.50	14	21	12	18	4	6
1200	0.75	7	10	6	9	2	3
1600	1.0	4	6	4	6	1	2
2400	1.5	2	3	2	3	1	1
3200	2.0	2	2	1	2	1	1
4000	2.5	1	2	1	1	< 1	1
4800	3.0	1	1	1	1	< 1	1

Notes:

1. An excursion or ferry vessel is equipped with two propulsion engines and an auxiliary engine.
2. The average horsepowers are estimated to be 750 hp and 100 hp for propulsion and auxiliary engines, respectively, based on the ARB's statewide survey.
3. The load for the propulsion engines at idling condition is 10%, and the load for the auxiliary engine is 43% based on the ARB's statewide survey.
4. The diesel PM emission factor for the propulsion engine is estimated as 0.5 g/bhp-hr based on the Bay Area Water Authority's testing, and the factor for the auxiliary is 0.84 g/bhp-hr based on the ARB's harborcraft estimates.
5. Assume that the each excursion/ferry takes an hour for loading and unloading and The activity takes place during 6am to 6pm, each day, 7days per week, and 52 weeks per year.
6. Cancer risks shown at OEHHA 65th and 95th percentile breathing rates

Table 5: Estimated Cancer Risk (per million) from Short-Haul Locomotive Activities

Downwind Distance (meter)	Downwind Distance (mile)	West L. A.		Long Beach		Richmond	
		65th BR	95th BR	65th BR	95th BR	65th BR	95th BR
20	0.013	7	10	5	7	2	3
40	0.025	7	10	4	6	2	3
60	0.038	10	14	4	5	2	3
80	0.050	10	14	6	8	3	4
100	0.063	9	13	7	11	3	5
200	0.125	8	12	4	6	2	3
300	0.188	6	8	3	4	1	2
400	0.25	4	6	2	3	1	2
800	0.50	2	3	1	2	1	1
1200	0.75	1	1	1	1	< 1	< 1
1600	1.0	1	1	1	1	< 1	< 1
2400	1.5	< 1	1	< 1	1	< 1	< 1
3200	2.0	< 1	< 1	< 1	< 1	< 1	< 1
4000	2.5	< 1	< 1	< 1	< 1	< 1	< 1
4800	3.0	< 1	< 1	< 1	< 1	< 1	< 1

Notes:

1. Assume that 10 trains per day and each train contains 2 locomotives.
2. The trains are traveling at 40 MPH at notch 5 setting.
3. The diesel PM emission factor = 362 g/hr based on the average of notch 5 for most common models seen at Roseville railyard.
4. Cancer risks shown at OEHHA 65th and 95th percentile breathing rates

References

OEHHA, 2000. Office of Environmental Health Hazard Assessment (OEHHA), *Air Toxics "Hot Spots" Program Risk Assessment Guidelines Part IV Technical Support Document for Exposure Assessment and Stochastic Analysis.* www.oehha.ca.gov/air/hot_spots/finalStoc.html. September 2000.

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OEHHA, 2003. Office of Environmental Health Hazard Assessment (OEHHA), *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments*. www.oehha.ca.gov/air/hot_spots/HRSguide.html. August 2003.